

2004 International  
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# FEM and Multiphysics Applications at NASA/GSFC

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# Mechanical Systems Analysis Branch



“Provide accurate, timely, and reliable structural analysis support to NASA space flight missions and new technology development areas.”

- Structural Dynamics and Loads
- Structural/Optical/Thermal Performance Analysis
- Structural Mechanics/Stress Analysis
- 30 structural analysts in the branch



# Available FEM Software



- MSC/Nastran
- Abaqus
- Ansys/Multiphysics
- COSMOS/M
- “Home-grown” programs
- Pre/Post-processors
  - Patran, FEMAP

# MSC/Nastran

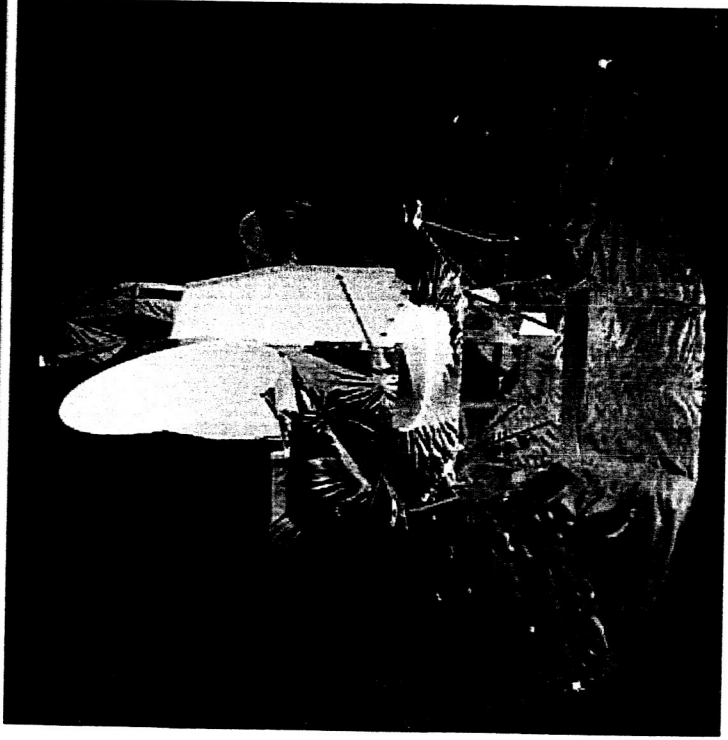


- Primary “workhorse” FEA package
  - Originally developed by NASA
  - Common “language” that we communicate with other NASA centers, major contractors, and international partners
  - Used primarily for linear statics and dynamics, coupled loads analysis, structural distortion, and structural performance problems.

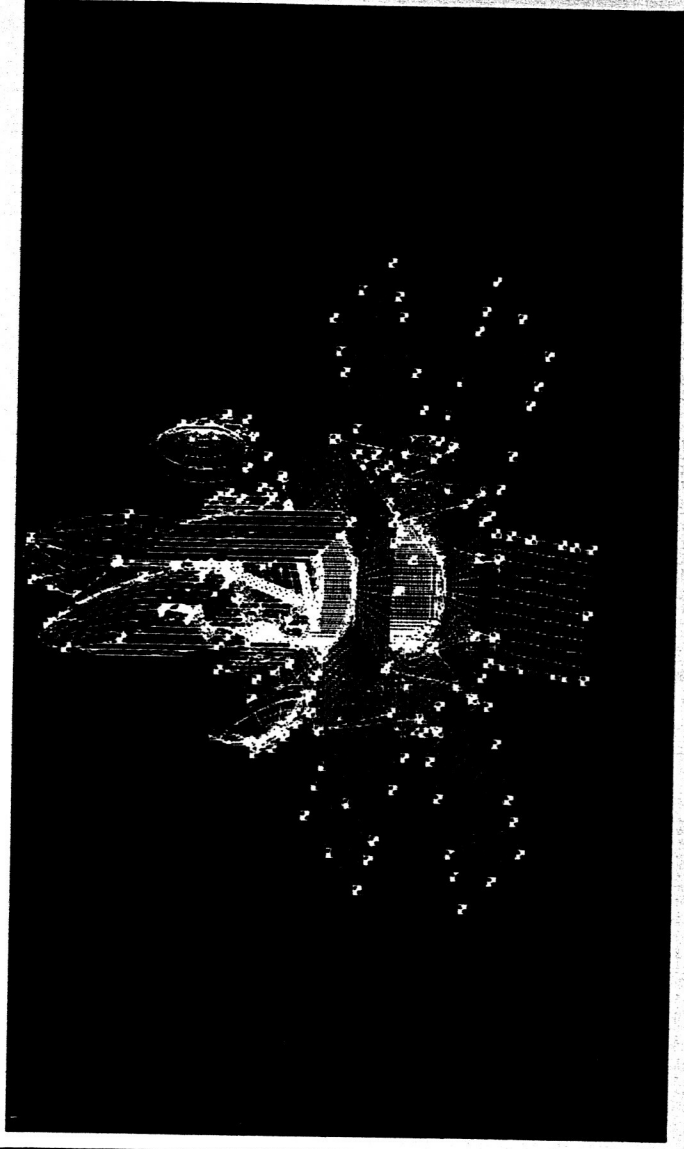
# Wilkinson Microwave Anisotropy Probe (WMAP)



WMAP's mission is to study the Cosmic Microwave Background (CMB) radiation which determines the age of the universe.



WMAP was launched  
June 2001.



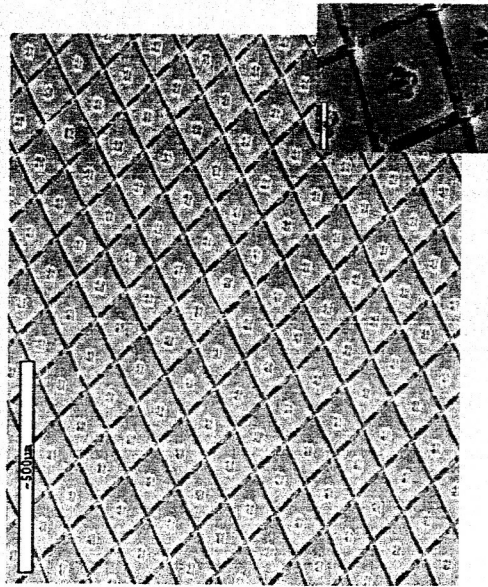
# Ansys/Multiphysics



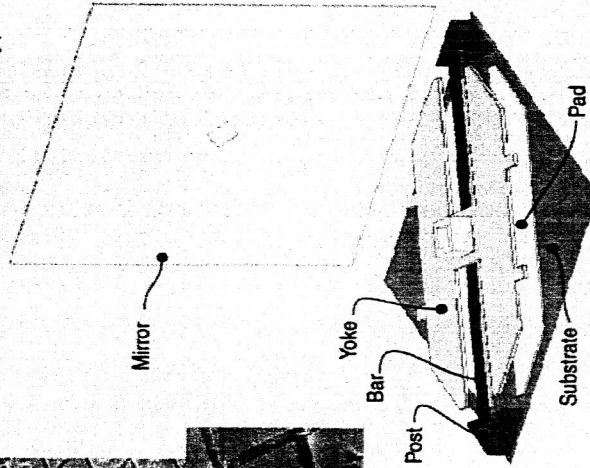
- Primary FEA package for all Micro-electro-mechanical systems (MEMS) analysis.
  - Electrostatic/structural, Magnetic/structural, and Fluid/structural/thermal interaction problems
    - MEMS micro-mirrors, MEMS micro-shutters, MEMS thrusters, MEMS tunable filters
- Also used for its robust non-linear analysis capabilities



# Micro-mirror

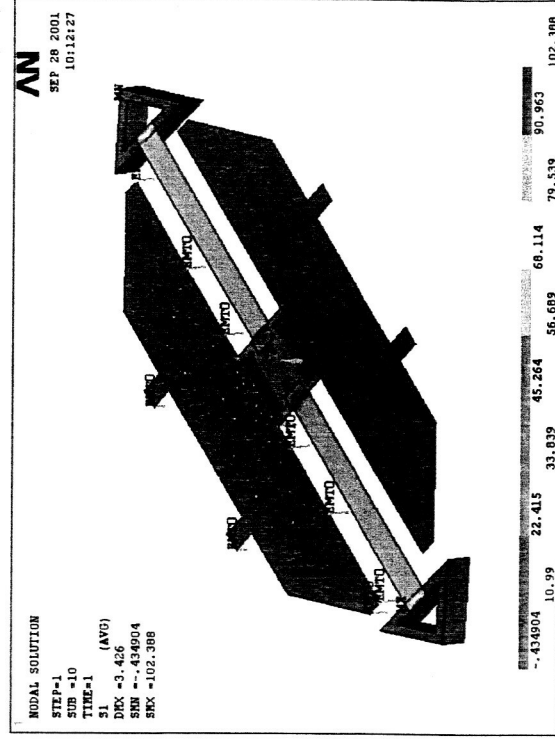


Single MMA unit-cell  
(mirror removed for clarity)



Fabricated Micro-Mirrors Array (MMA)

- 100 $\mu$ m x 100 $\mu$ m micro-mirror actuated at 50°K using nonlinear 1100 series Al properties

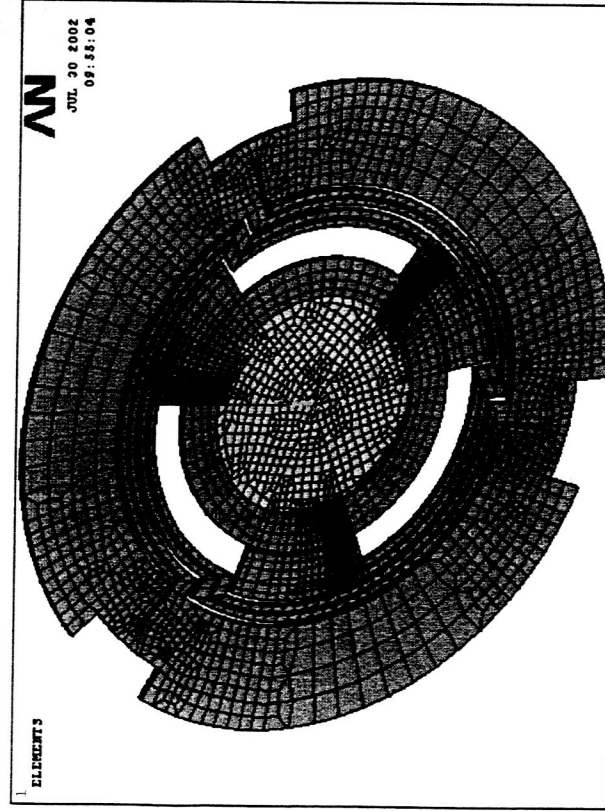


# MEMS Tunable Filter

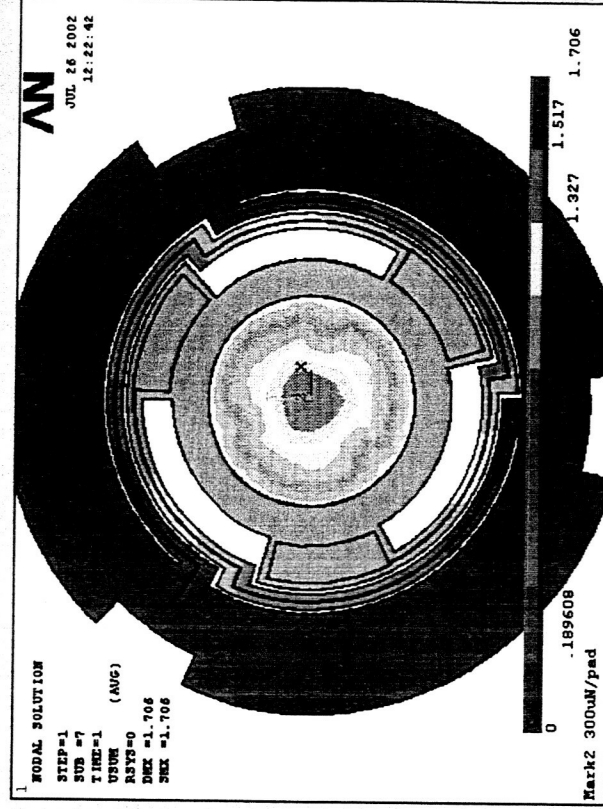




# MEMS Tunable Filter

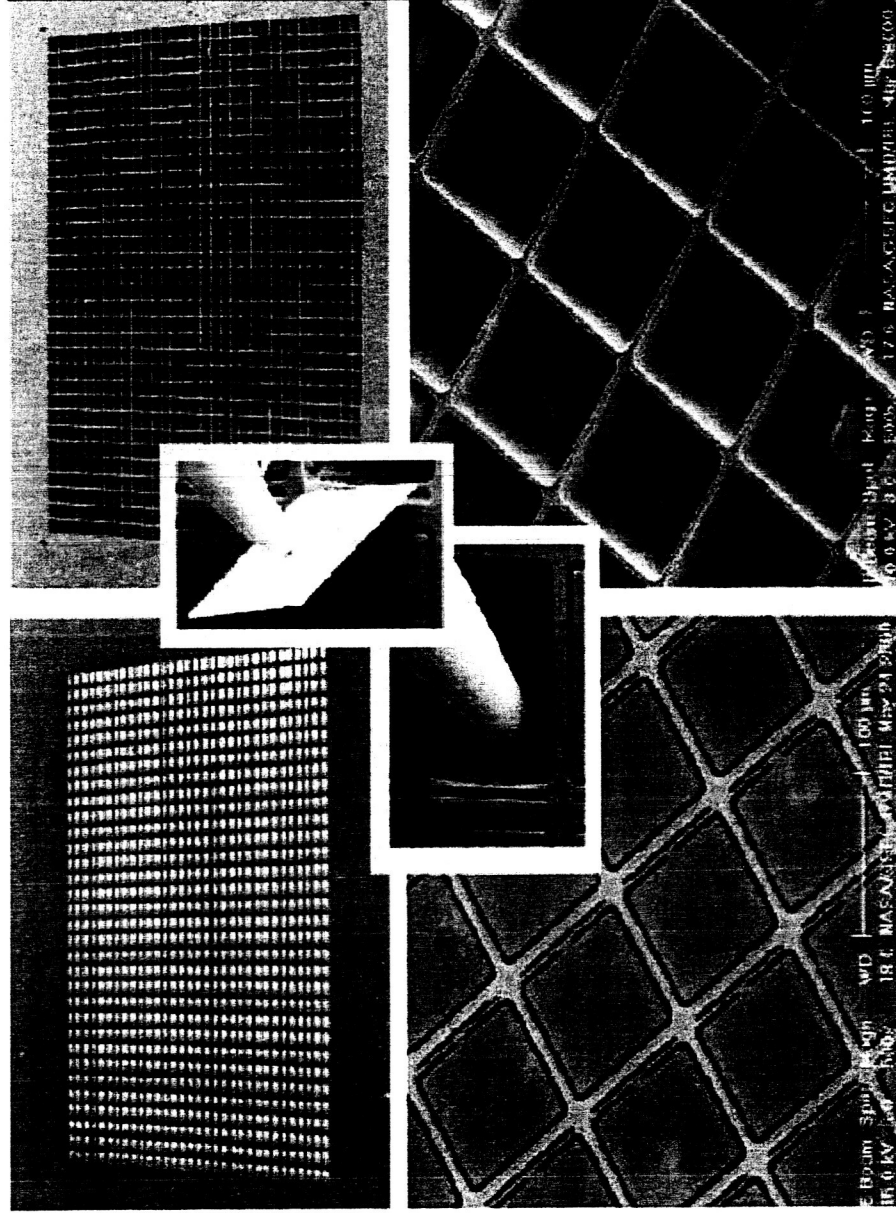


3-D FEM

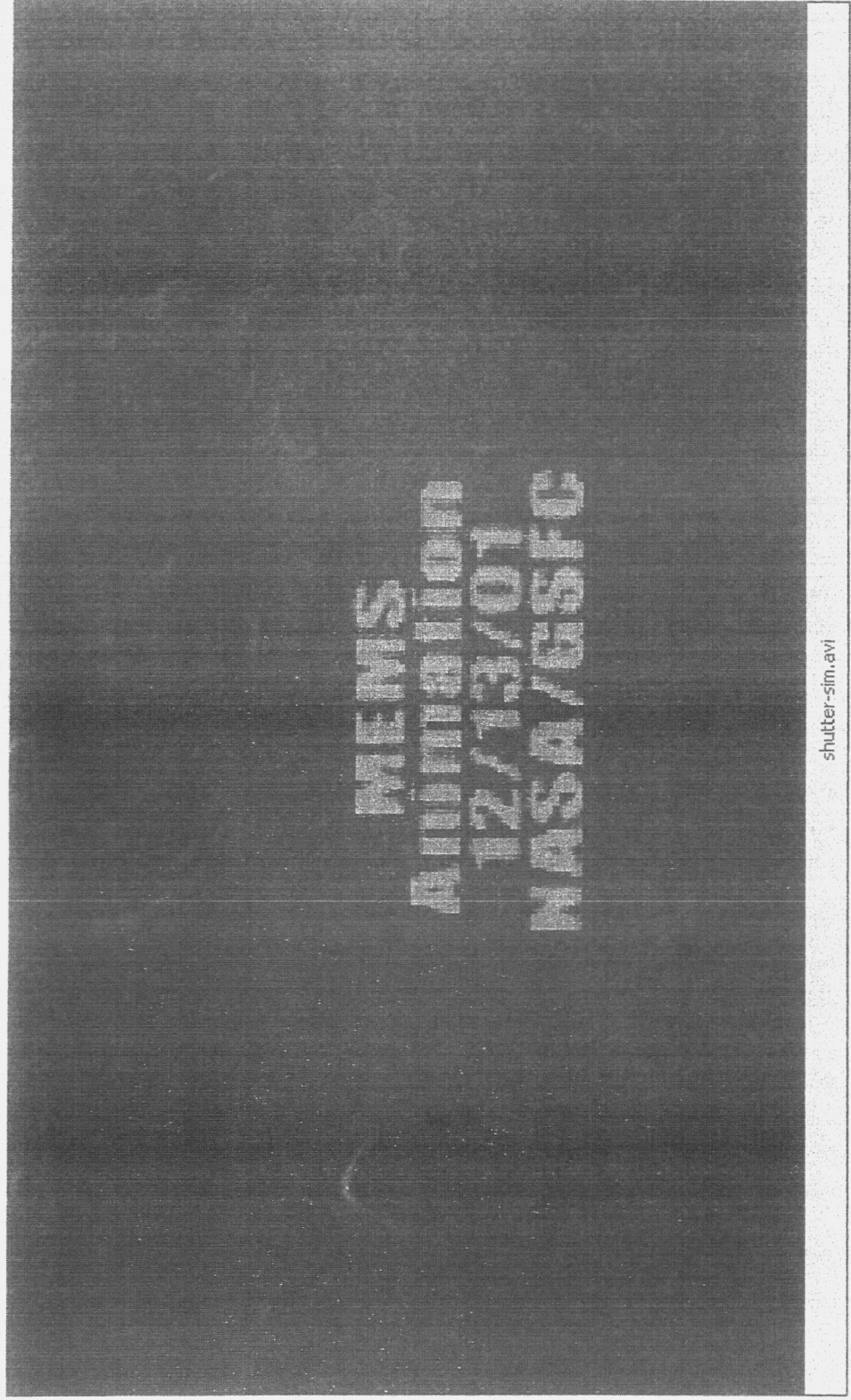


Static Non-Linear Force-  
Deflection FEA

# Micro-shutter Array



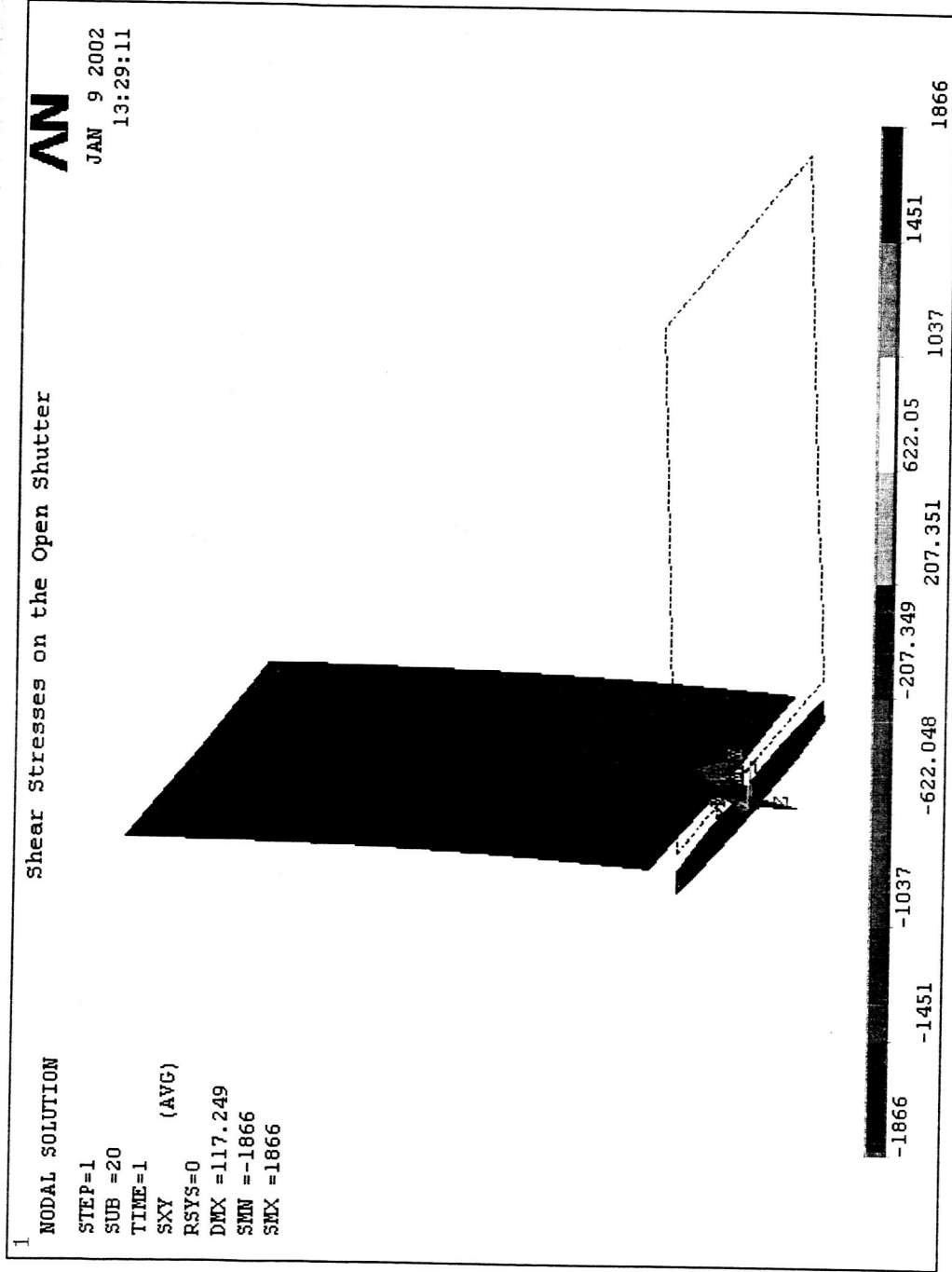
# Micro-shutter Simulation



shutter-sim.avi



# Micro-shutter Model





# Verification of FEA Results



- GSFC has extensive test and characterization capabilities.
  - Modal test facility, High Capacity Centrifuge, Static test facility, Vibration Facility, Acoustic Chamber, Thermal Vacuum Chambers for “macro” structures.
  - Extensive lab capabilities for “micro” structures. Including SEM, AFM, confocal microscopy, nano-indentation, magnetic facilities, optical and electrical performance labs.

# GSFC Code 542 Best Practices



- Verification, Verification, Verification
  - Verify component models as early as possible
    - Strength/Stiffness
  - Verify primary structural strength/stiffness
    - Correlate all primary structural frequencies prior to...
  - Verification coupled loads cycle
    - Last update of the payload's structural loads
    - Once the loads are updated, all structural strength margins of safety verified during strength testing are reevaluated to ensure structural integrity during launch.

# Metrics



- We get one chance to get it right.
  - Public customers want a return on their investment.
  - Science customers may only get one shot for a mission over their career.
    - Others may be trying to get the same information
- Primary metric
  - **Mission Success!**